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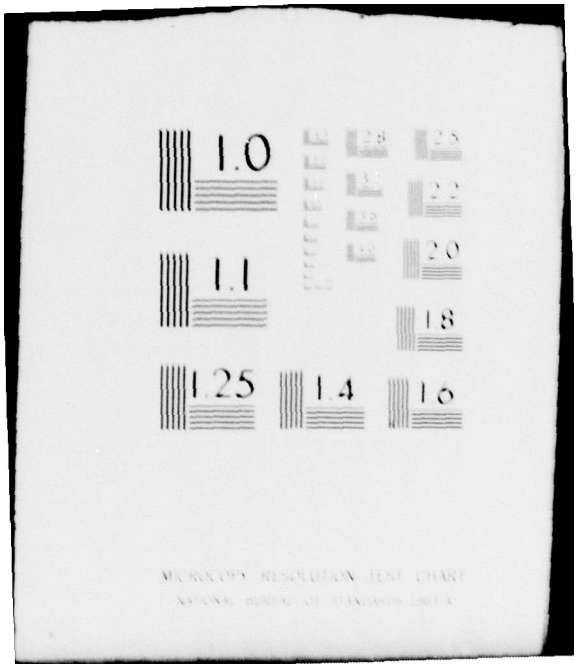
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MANUFACTURING METHODS & TECHNOLOGY PROGRAM
ZINC SELENIDE BLANKS FOR WINDOWS AND LENS ELEMENTS

1 May 1979 to 30 July 1979

Placed by
US Army Electronics Research & Development Command
Night Vision and Electro-Optics Laboratory
Fort Belvoir, VA 22060

Contract No. DAAB07-78-C-2038

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Testing and evaluation of the zinc selenide blanks from the confirmatory deposit were completed during this report period. Preparation for the Pilot Production Run is in progress.

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MANUFACTURING METHODS & TECHNOLOGY PROGRAM
ZINC SELENIDE BLANKS FOR WINDOWS AND LENS ELEMENTS

Fourth Quarterly Progress Report
1 May 1979 to 31 July 1979

Object of Study

The objective of this manufacturing methods and technology program is to establish the capability to manufacture high volume zinc selenide blanks for infrared windows and lens elements.

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ABSTRACT

Testing and evaluation of the zinc selenide blanks from the confirmatory deposit were completed during this reporting period. Preparation for the Pilot Production Run is in progress.

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GLOSSARY

Absorption Coefficient - Fraction of energy lost while traversing a pathlength of one centimeter through a material.

Chemical Vapor Deposition - A process by which chemicals are reacted in the vapor phase to form a compound.

Evaporator - Apparatus used to form a vapor (or gas) from a solid (or liquid).

Image Spoiling Characteristics - That property of a transparent material that defines the ability to resolve discrete images.

Substrate - A form on which material is deposited, sometimes called a mandrel.

Zinc Reservoir System - Apparatus containing one or several liquid zinc retorts and associated monitoring and controlling devices.

1.0 PURPOSE

The purpose of this manufacturing and methods technology program is to establish an automated production process for the fabrication of high optical quality zinc selenide.

The program is of seventeen months duration and is sponsored by the United States Army Electronics Research and Development Command. It addresses itself to the further automation of an existing production process for the chemical vapor deposition of zinc selenide. Raytheon Company has successfully developed the techniques and facilities to fabricate state-of-the-art CVD zinc selenide in large sizes. It is anticipated that with improvements in automated processing the price for standard size lens blanks will be reduced to 50 percent of the catalog price. In addition, the use of a curved substrate may further reduce the price of the color correcting lens blank shown in Figure 1 to less than $200 each for large volume purchases.

The program has been divided into three phases. In the first phase, zinc selenide test blanks will be produced using the existing process. In Phase II of the program the zinc reservoir system will be replaced with an automated external zinc supply, and blanks will be deposited for confirmation of the optical and mechanical characteristics of the material. The third phase of the program will demonstrate the production capability of a pilot line to manufacture high-quality zinc selenide blanks at four-hundred and eighty-one (481) units per month.

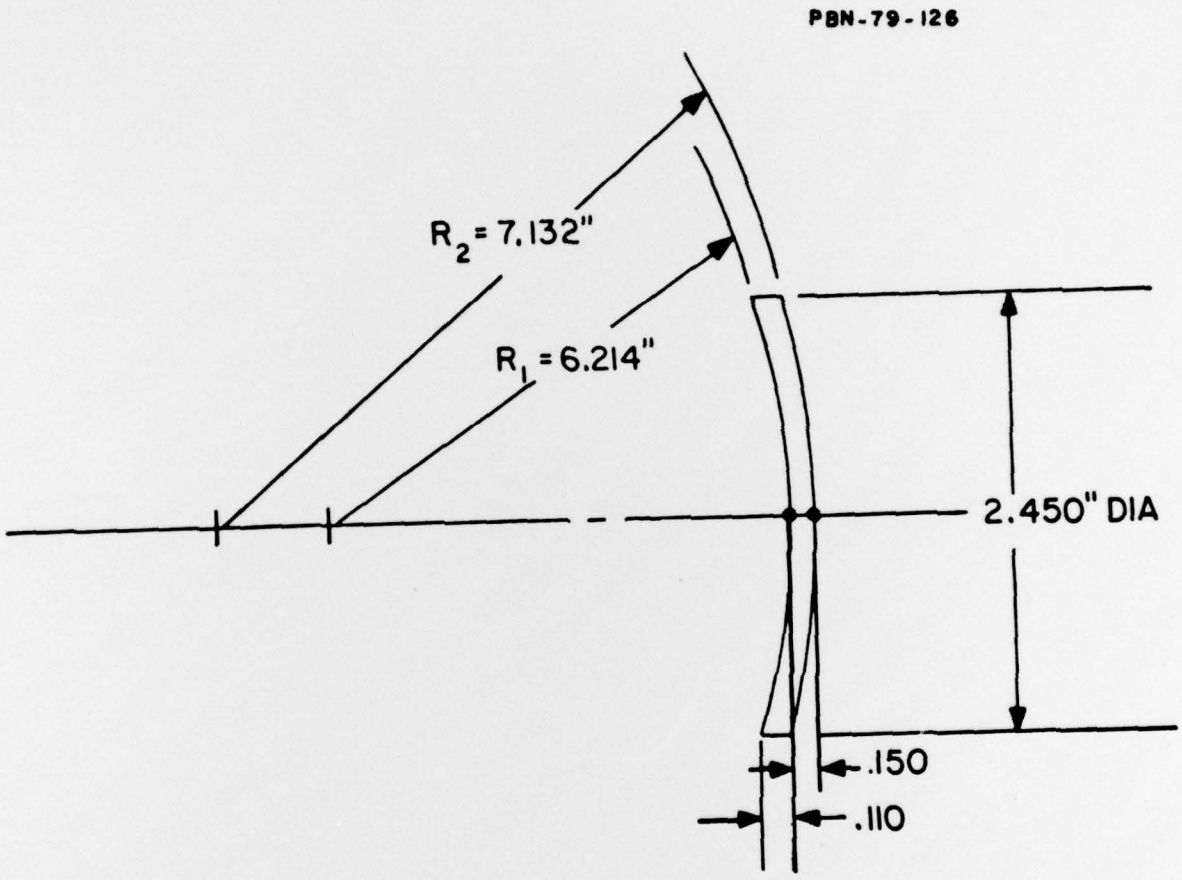

Figure 1. Zinc Selenide Compensating Lens.

2.0 NARRATIVE AND DATA

2.1 Confirmatory Sample Deposit

Testing of the confirmatory sample deposit was completed during this reporting period. Dimensions and parallelism for the six polished test samples are presented in Table 1. All test blanks meet the polishing and dimensional requirements. Examination of the blanks showed no chips, fractures or inclusions exceeding the specification.

Table 2 presents the measured absorption coefficient at 10.6 um for each of the polished samples. Absorption coefficients were approximately 0.002 cm^{-1}, well within the program requirements.

Four of the polished blanks were tested for image spoiling in the 0.6-1.1 um and 8-12 um spectra. Table 3 displays the image spoiling data, presenting the image width at the 50% intensity level with and without the sample in the test apparatus.

The six polished test blanks were tested for strain revealing no relative retardation. Some localized birefringence was seen in individual crystallites, however, no large order birefringence was discernible.

2.2 Pilot Production Deposit

The pilot run will be conducted to demonstrate a production rate capability of producing 481 zinc selenide lens blanks per month. The pilot run will be performed during a two week period demonstrating a rate capability of at least 241 units. A graphite box mandrel, 12 X 22 X 60 inches will be used for the zinc selenide deposition. A total of 400 lens sites are available in this size mandrel: the two 12 X 60 inch plates each contain 60 sites, and the larger 22 X 60 inch plates contain 140 sites. A flow diagram for the processes incorporated in the Pilot Production Run is presented in Figure 2.

TABLE 1

CONFIRMATORY RUN SPECIMENS

Specimen	Diameter (mm)	Thickness (mm)	Parallelism (min.)
CON 1	56.3 ± .1	6.7 ± .1	.78 ± .05
CON 2	56.3 ± .1	6.6 ± .1	.23 ± .05
CON 3	68.2 ± .1	6.4 ± .1	.21 ± .05
CON 4	68.2 ± .1	6.6 ± .1	.15 ± .05
CON 5	74.9 ± .1	6.7 ± .1	.21 ± .05
CON 6	74.9 ± .1	6.5 ± .1	.20 ± .05

TABLE 2

ABSORPTION COEFFICIENT * @ 10.6 um

Specimen No.	Absorption Coefficient (cm^{-1})
CON 1	0.0023
CON 2	0.0023
CON 3	0.0022
CON 4	0.0023
CON 5	0.0020
CON 6	0.0021

*Includes surface absorption

TABLE 3

IMAGE SPOILING DATA

Sample No.	Image Width @ 50% Intensity (μrad) No Sample	With Sample	Spectra
CON #3	201.3	206.8	8-12 μm
CON #4	195.1	198.6	
CON #5	198.0	196.6	
CON #6	204.5	202.4	
CON #3	19.2	17.7	0.6328 μm
CON #4	15.7	16.8	
CON #5	15.7	17.7	
CON #6	15.7	17.3	

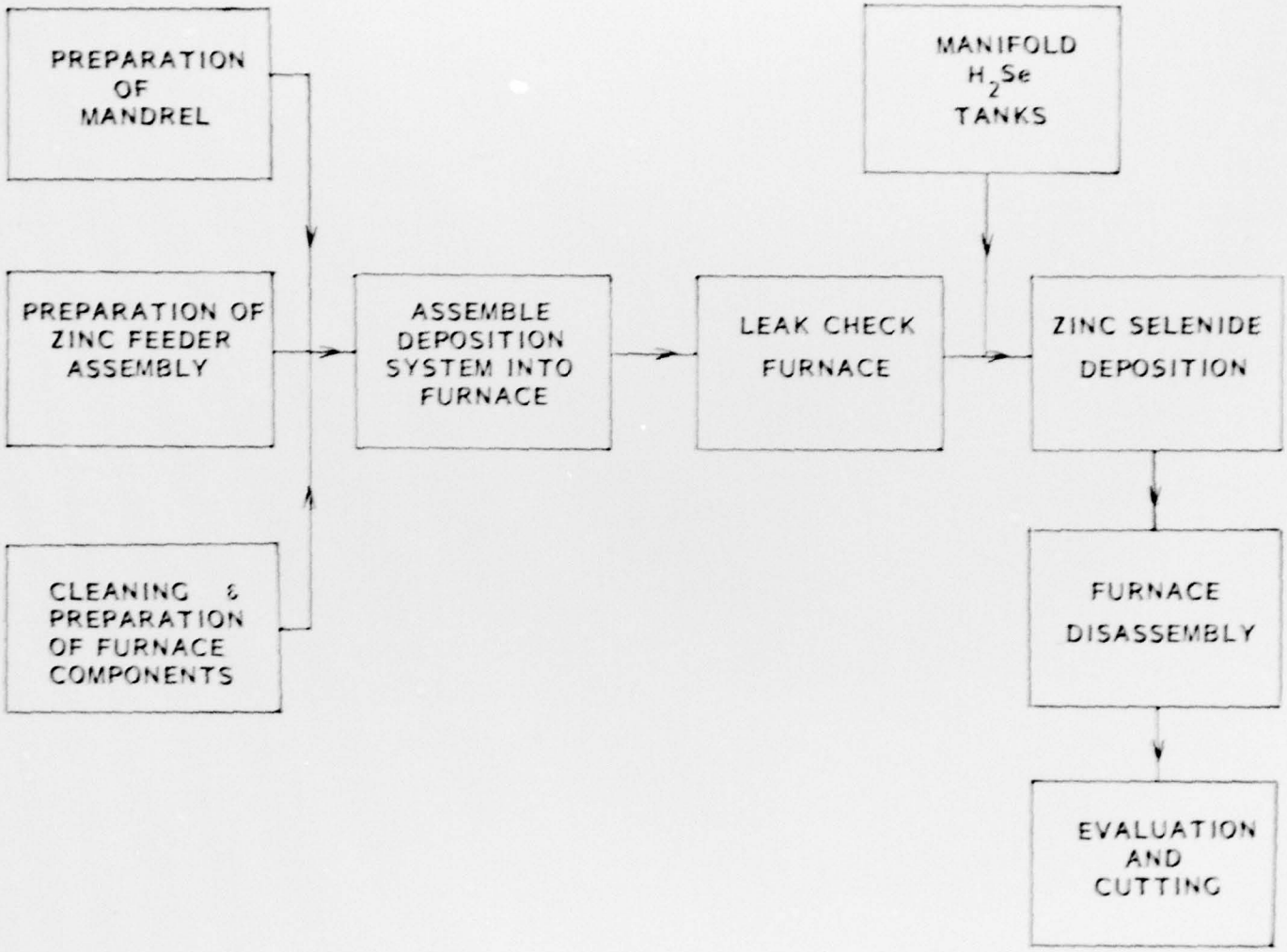

Figure 2. Flow Diagram for Zinc Selenide Pilot Production

The zinc selenide from the Pilot Production deposit will be fabricated into: (40) lens blanks having sufficient material to yield the lens element as per drawing No. SM-C-804146, (4) 49 mm diameter X 6.35 mm thick, (4) 61 mm diameter X 6.35 mm thick, and (4) 67.5 mm diameter X 6.35 mm thick. These blanks or witness samples will be tested to meet the following specifications:

a) Transmission

The uncoated transmittance for a 6.35 mm thickness shall be greater than 58 percent over the wavelength region 8 to 13 um at normal incidence. Over the wavelength region 0.6 to 1.1 um the transmittance shall be greater than 43 percent.

b) Inclusions

The maximum size inclusion is 0.625 mm. The permissible number of maximum size inclusions is one per each cubic centimeter of material. The sum of the diameters of all inclusions in any given cubic centimeter of material shall not exceed 0.625 mm. Bubbles are classified as inclusions.

c) Surface Hardness

The Knoop, 50 gram, hardness rating shall be at least 100.

d) Absorption

The absorption over the 8 to 12 um region will be less than 0.01 per centimeter. The absorption at 10.6 um will be less than 0.005 per centimeter.

e) Scatter

The angular spread of a focused spot on a blank 6.35 mm thick shall increase by more than 15 percent over the angular spread of the same spot

without the sample in the beam, over the wavelength region 0.6 to 1.2 um. The angular spread over the wavelength region 8 to 12 um will be less than 2 percent.

f) Rupture Modulus

The modulus of rupture shall be an average 7300 pounds per square inch and a minimum value not less than 6570 psi.

g) Parallelism

The provided blanks shall have maximum allowable wedge of 10 minutes. The blank(s) used for image spoiling tests will have a maximum wedge of 0.5 minute.

h) Strain

the distribution of permanent strain shall be symmetrical, and the birefringence resulting from permanent strain will not produce more than 10 nanometers relative retardation or path difference per centimeter of a transmitted narrow-band light source.

j) Chips and Fractures

A vented fracture exceeding 10 mm in length or aiming at the center of the blank shall be rejected. Blanks having pressure or fire cracks deeper than 1 mm shall be rejected. Other surface irregularities, pits, or cracks shall not extend into 2.55 mm diameter of the blanks required to yield the lens, as per drawing No. SM-C-804146.

3.0 MEETINGS

A meeting was held on June 13, 1979, at the Research Division with Mr. R. Spande, the new program monitor replacing Mr. D. Helm. The confirmatory sample deposit and sample testing were discussed, as well as future program requirements including the pilot run. The confirmatory samples and test report were submitted to Mr. Spande at this time.

4.0 CONCLUSIONS

Test measurements on samples from the confirmatory deposit were successfully completed.

5.0 PROGRAM FOR NEXT INTERVAL

The Pilot Production deposit will be setup and deposited during the next reporting period. The zinc selenide from this deposit will be cut and fabricated into the required test blanks. Testing and property evaluation on these samples will be conducted.

6.0 PUBLICATIONS

There were no publications during this reporting period.

7.0 PERSONNEL

The following is the worked manhours for key personnel on this program.

Name	Manhours During Report Period
Mr. J. Connolly	120.0
Research Technicians	48.0
Publications Specialists	15.0
Total	183.0

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Berkeley, CA 94710

Director
US Army Night Vision & Electro-Optics
Laboratory (Quantity 5)
ATTN: DELNV-SI (R. Spande)
Fort Belvoir, VA 22060